We Claim

~~WHAT IS CLAIMED AS NEW AND DESIRED TO BE SECURED BY LETTERS PATENT OF THE UNITED STATES IS:~~

1. In a method for controlling a spread spectrum transmitter having an oscillator provided with a modulation input, the improvement comprising:

maintaining the transmitter in a low current state between transmissions of spread spectrum signals;

generating one or more chip code sequence repetitions during a transmitting interval when the transmitter is not maintained in the low current state and applying the generated chip code sequence repetition as a modulating voltage to the modulation input of the oscillator thereby causing a frequency deviation in the transmitter output;

applying a device address and data to the modulation input of the oscillator after modulating the oscillator with the chip code sequence repetition for a predetermined time period such that the modulation index of the transmitter during application of the address device and the data is less than that of the modulation index of the transmitter during application of only the chip code sequence.

2. The method of claim 1, further comprising:

limiting the number of address and data bits applied to the modulation input of the oscillator so that an associated receiver which receives the transmitted signal can successfully decode the transmitted data after completion of coarse search and without the use of continuous chip code synchronization by the receiver.

3. The method of claim 1, further comprising:

applying the generated chip code sequence repetition to the oscillator at a chip rate of approximately 1.0-1.3 Mc/s to produce a frequency shift keying (FSK) spread spectrum modulated signal.

4. The method of claim 1, wherein said oscillator comprises a tuned oscillator and a phase shift keying modulator, further comprising:

applying the generated chip code sequence repetition to the phase shift key modulator at a chip rate of approximately 1.0-1.3 Mc/s to produce a phase shift keying (PSK) spread spectrum modulated signal.

5. A spread spectrum chip code synchronization method for synchronizing a spread spectrum signal received by a receiver having an output, comprising the following steps:

causing a receiver chip code generator to sequentially advance or delay in time a chip code generated by the generator;

correlating a first signal received by the receiver within one chip time alignment of the chip code generated by the generator by comparing the first signal to an adaptive average to determine whether the first signal exceeds the adaptive margin by a preset margin;

updating the adaptive average by adding a portion of the first signal to a portion of the adaptive average used during correlating of said first signal to produce a new adaptive average;

ceasing the sequential advance or delay of the chip code generated by the chip code generator when, during the correlating

step, it is determined that the first signal exceeds the adaptive average by said preset margin, thereby achieving initial chip code synchronization operation; and

decoding data provided at a receiver output.

6. The method of Claim 5, comprising:

decoding said data without continuous receiver chip code generator re-synchronization.

7. A spread spectrum chip code synchronization method for synchronizing a spread spectrum signal received by a receiver having an output, comprising the following steps:

causing a receiver chip code generator to sequentially advance or delay in time a chip code generated by the generator;

correlating a first signal received by the receiver within one chip time alignment of the chip code generated by the generator by comparing the first signal to an adaptive average to determine whether the first signal exceeds the adaptive average by a preset margin;

updating the adaptive average by adding a portion of the first signal to a portion of the adaptive average used during correlating of said first signal to produce a new adaptive average;

correlating a second signal received by the receiver in response to a determination in the step of correlating the first signal that the first signal exceeds the adaptive margin by said preset margin, within a portion of one chip time alignment of the spread spectrum chip code, by comparing the second signal to the new adaptive average to determine if there is a correlation improvement;

adjusting the chip code position of the chip code generator by a portion of a chip time in dependence on whether or not there was an improvement in correlation in the preceding step of correlating the second signal; and

decoding data provided at an output of the receiver.

8. The method of claim 7, comprising:

decoding data while chip code synchronization within the receiver runs open loop.

9. A spread spectrum transmitter comprising:

oscillator means having a modulation input and producing a variable frequency output tuned to a carrier frequency to be transmitted;

a chip code generator coupled to the modulation input of the oscillator means to change the frequency of the output of the oscillator means to produce a spread spectrum frequency shift keying (FSK) modulated signal at said carrier frequency;

a buffer amplifier coupled to the output of the oscillator means to amplify the spread spectrum FSK modulated signal at said carrier frequency;

a filter coupled to an output of the buffer amplifier to filter the amplified spread spectrum FSK modulated signal at said carrier frequency; and,

an antenna coupled to an output of the filter for transmitting the amplified and filtered spread spectrum FSK modulated signal at said carrier frequency.

10. The transmitter of claim 9, comprising:

a crystal oscillator for applying a clock signal to said chip code generator; and

means for locking the oscillator means to the clock produced by said crystal oscillator.

11. The transmitter of claim 10, comprising:

said chip code generator being clocked at a chip rate of approximately 1.0 - 1.3 Mc/s.

12. The spread spectrum transmitter according to claim 9, further comprising:

a data storage device coupled to the modulation input of the oscillator means for applying to said modulation input data bits having an amplitude such that a frequency change produced in the transmitter carrier frequency by the oscillator means is less broad than that of a frequency change produced in the transmitter carrier frequency when only a chip code from the chip code generator is applied to the modulation input of the oscillator means, thereby simultaneously producing FSK data modulation and FSK spreading modulation at a desired carrier frequency.

13. The spread spectrum transmitter of claim 12, further comprising:

timer means for causing the chip code generator to produce one or more chip code sequences applied to the modulation input of the oscillator means for a predetermined time period, for the purpose of spread spectrum synchronization at a receiver, prior to the data storage device outputting sequential data bits to the modulation input of the oscillator means.

14. The spread spectrum transmitter according to claim 12, further comprising:

first timer means for applying for a predetermined time period to the modulation input of the oscillator means, for the

purpose of spread spectrum synchronization at a receiver, a chip code produced by the chip code generator and having one or more chip code sequences and an amplitude and pattern so that a data detector in the receiver is precharged in order to overcome system tolerances between the transmitter and the receiver; and

second timer means to produce a predetermined delay in application of data from the data storage device to the modulation input of the oscillator means after application of only said chip code of one or more chip code sequences.

15. A spread spectrum transmitter according to claims 9, 12, 13 or 14, further comprising:

frequency stabilization means for reducing a frequency offset error at the oscillator means.

16. A spread spectrum transmitter according to claims 9, 10, 11, 12, 13 or 14, wherein said oscillator means includes an enable input and the buffer amplifier includes an enable input, comprising:

control means connected to the enable input of the oscillator means and the enable input of the buffer amplifier for enabling said oscillator means and said buffer amplifier only during transmission from the transmitter thereby to reduce power drain and ensure adequate settling time.

17. A spread spectrum transmitter according to claims 9, 12, 13 or 14, further comprising:

modulation index setting means for setting a frequency deviation of the oscillator means in response to modulating signals applied to the modulation input of the oscillator means to generate fast frequency shift keying (FFSK) transmissions.

18. A spread spectrum transmitter according to claims 9, 12, 13 or 14, further comprising:

an address storage device for storing addresses;

error detection generation means for detecting errors in data to be transmitted; and

means for applying addresses stored in the address storage device and error detection signals generated by the error detection generation means to the modulation input of the oscillator means at an amplitude less than the amplitude of the chip code applied to the modulation of the input by the chip code generator, thereby sequentially modulating the output frequency of the oscillator means less broadly than when the chip code alone is applied to the modulation input of the oscillator means.

19. A spread spectrum transmitter according to claims 9, 12, 13 or 14, further comprising:

means for limiting a length of a data message transmitted so that once initial spread spectrum synchronization is achieved by a receiver, a receiver can run open loop without performing ongoing chip code resynchronization.

20. A spread spectrum transmitter comprising:

oscillator means having a modulation input and producing a variable frequency output;

a chip code generator coupled to the modulation input of the oscillator means to change the frequency of the output of the oscillator means to produce a spread spectrum frequency shift keying (FSK) modulated signal;

multiplication means for multiplying the frequency output of the oscillator means by a predetermined integer multiple of

the frequency of the oscillator means to produce a desired carrier frequency;

a buffer amplifier coupled to the output of the multiplication means to amplify the frequency multiplied spread spectrum FSK modulated signal and produce a corresponding signal at an output of the buffer amplifier;

a filter coupled to the output of the buffer amplifier to filter the output of the buffer amplifier; and,

an antenna coupled to an output of the filter for transmitting the amplified and filtered spread spectrum FSK modulated signal at said carrier frequency.

21. A spread spectrum transmitter comprising:

a voltage controlled oscillator (VCO) having a modulation input and a frequency output tuned to a desired carrier frequency;

a chip code generator coupled to the modulation input of the VCO to apply a chip code sequence to the modulation input and thereby modulate the frequency output of the VCO to generate a spread spectrum signal; and

data storage means coupled to the modulation input of the VCO to apply data stored in the data storage device to the modulation input of the VCO at a level which produces less broad modulation of the frequency output of the VCO than when only the chip code sequence is applied to the modulation input, thereby simultaneously producing a fast frequency shift keying (FFSK) data signal.

22. The spread spectrum transmitter according to claim 21, further comprising:

frequency stabilization means for reducing offset error in the frequency of the output of the VCO.

23. The spread spectrum transmitter according to claim 21, further comprising:

a buffer amplifier for amplifying the frequency output of the VCO;

said VCO and said buffer amplifier each having an enable input;

control means connected to the enable input of the VCO and the enable input of the buffer amplifier for enabling said VCO and said buffer amplifier only during transmission from the transmitter thereby to reduce power drain and ensure adequate settling time.

24. The spread spectrum transmitter according to claim 22, further comprising:

modulation index setting means for setting a frequency deviation of the VCO in response to modulating signals applied to the modulation input of the VCO to generate fast frequency shift keying (FFSK) in order to minimize transmitted band width.

25. A spread spectrum transmitter according to claim 24, further comprising:

an address storage device for storing addresses;

error detection generation means for detecting error in data to be transmitted; and

means for applying addresses stored in the address storage device and error detection signals generated by the error

detection generation means to the modulation input of the VCO at an amplitude less than the amplitude of the chip code applied to the modulation of the input by the chip code generator, thereby sequentially modulating the output frequency of the VCO less broadly than when the chip code alone is applied to the modulation input of the VCO.

26. The spread spectrum transmitter according to claim 25, further comprising:

multiplication means for multiplying the frequency output of the voltage controlled oscillator by a predetermined integer multiple of the frequency of the VCO to produce a desired carrier frequency.

27. The spread spectrum transmitter according to claims 26, further comprising:

means for limiting a length of a data message transmitted so that once initial spread spectrum synchronization is achieved by a receiver, a receiver can run open loop without performing chip code synchronization.

28. A spread spectrum transmitter comprising:

oscillator means having an output set to a carrier frequency;

a phase shift key modulator having an input coupled to the output of the oscillator means and having a modulation input;

a chip code generator connected to the modulation input of the phase shift key modulator to apply a chip code sequence to the modulation input of the phase shift key modulator and thereby produce a phase shift key spread spectrum modulated signal at the

said carrier frequency at an output of said phase shift key modulator;

a buffer amplifier having an input coupled to an output of the phase shift key modulator;

a filter having an input coupled to an output of the buffer amplifier; and

an antenna having an input coupled to an output of the filter to transmit the amplified and filtered phase shift key spread spectrum modulated signal at the carrier frequency;

timer means for applying one or more chip code sequences to the modulation input of the phase shift key modulator prior to transmission of data thereby to promote spread spectrum synchronization in a receiver receiving a spread spectrum modulated signal transmitted by the antenna;

address storage means for storing addresses;

data means for storing data; and

error detection generation means for providing error detection bits to secure the data to be transmitted.

29. The spread spectrum transmitter of claim 28, further comprising:

means for applying addresses stored in the address storage means, data stored in the data means, and error detection signals generated by the error detection generation means to the modulation input of the phase shift key modulator, thereby sequentially outputting address, data and error detection code.

30. The spread spectrum transmitter according to claims 28 or 29, further comprising:

frequency stabilization means for reducing frequency offset error at the output of the VCO.

31. The spread spectrum transmitter according to claims 28 or 29, further comprising:

said oscillator means and said buffer amplifier each having an enable input; and

control means connected to the enable input of the oscillator means and the enable input of the buffer amplifier for enabling said oscillator means and said buffer amplifier only during transmission from the transmitter thereby to reduce power drain and ensure adequate settling time.

32. A spread spectrum transmitter comprising:

carrier frequency generation means for generating a carrier frequency at an output;

frequency stabilization means for reducing frequency offset error at the output of the oscillator means;

a phase shift key modulator having an input coupled to the output of the means and having a modulation input;

a chip code generator connected to the modulation input of the phase shift key modulator to apply a chip code sequence to the modulation input of the phase shift key modulator and thereby produce a phase shift key spread spectrum modulated signal at the frequency of the carrier frequency generation means at an output of said phase shift key modulator;

multiplication means for multiplying the output of the phase shift key modulator by a predetermined integer multiple of the

frequency of the carrier frequency generation means to produce a desired transmitted frequency;

a buffer amplifier having an input coupled to an output of the multiplication means;

a filter having an input coupled to an output of the buffer amplifier; and

an antenna having an input coupled to an output of the filter to transmit the multiplied, amplified and filtered phase shift key spread spectrum modulated signal at said desired transmitted frequency;

timer means for controlling application from said chip code generator of one or more chip code sequences to the modulation input of the phase shift key modulator prior to transmission of data thereby to promote spread spectrum synchronization in a receiver receiving a spread spectrum modulated signal transmitted by the antenna;

address storage means for storing addresses;

data means for storing data;

error detection generation means for providing error detection bits to secure the data to be transmitted; and

means for applying addresses stored in the address storage means, data stored in the data means, and error detection signals generated by the error detection generation means to the modulation input of the phase shift key modulator, thereby sequentially outputting address, data and error detection code.

33. The spread spectrum transmitter according to claims 28, 29, 30, 31 or 32, further comprising:

means for limiting a length of a data message transmitted so that once initial spread spectrum synchronization is achieved by a receiver, the receiver can run open loop without performing ongoing chip code resynchronization.

34. A spread spectrum transmitter comprising:

oscillator means, including a voltage controlled oscillator having a modulation input, for generating a transmitter output at a carrier frequency;

processor means for controlling transmissions by the voltage controlled oscillator, said processor means including processor oscillator means for producing a frequency stabilizing reference clock signal;

means for stabilizing the frequency of the voltage controlled oscillator by locking the frequency of the voltage controlled oscillator to the frequency stabilizing reference clock signal produced by said processor oscillator means;

timer means for defining an active operating state in which the processor means and the voltage controlled oscillator are enabled, said timer means first enabling said processor oscillator means for a predetermined time to stabilize the frequency output of the processor oscillator means and thereafter enabling said voltage controlled oscillator for a predetermined time to allow the frequency output of the voltage controlled oscillator to stabilize, said timer means also defining an inactive state in which the processor means is not enabled and

the voltage controlled oscillator is not enabled and no carrier frequency at the transmitter output is produced; and

said processor means further comprising chip code generator means clocked by the processor oscillator means for generating a chip code signal applied to the oscillator means, thereby locking the transmitter carrier frequency to the processor reference clock signal.

35. The transmitter of Claim 34, wherein said oscillator means comprises:

phase shift keying means connected to the output of the voltage controlled oscillator and having a modulation input to which is applied the chip code signal, thereby producing a spread spectrum phase shift key signal at said carrier frequency.

36. The transmitter of Claim 34, further comprising:

means for applying the chip code signal to the modulation input of the voltage controlled oscillator so that at the output of the voltage controlled oscillator there is produced a frequency shift keyed spread spectrum signal at said carrier frequency.

37. The transmitter of Claims 1, 9, 21, 28, 32, 34 or 35, further comprising:

means for generating plural transmit messages applied to said oscillator means for transmission by the transmitter, thereby to provide message redundancy.

38. The transmitter of Claim 37, wherein said means for generating plural transmit messages comprises:

means for generating said plural messages with different time intervals therebetween to provide message redundancy with

a lowered probability of repeat collision in the presence of multiple transmitters.

39. The spread spectrum transmitter according to claims 34, 35, or 36, further comprising:

said voltage controlled oscillator having an enable input;

a buffer amplifier, having an enable input, for amplifying the output of the voltage controlled oscillator; and,

control means connected to the enable input of the voltage controlled oscillator and the enable input of the buffer amplifier for enabling said voltage controlled oscillator and said buffer amplifier only during a transmission from the transmitter thereby to reduce power drain and ensure adequate settling time.

40. The spread spectrum transmitter according to claim 37, further comprising:

said voltage controlled oscillator having an enable input;

a buffer amplifier, having an enable input, for amplifying the output of the voltage controlled oscillator; and,

control means connected to the enable input of the voltage controlled oscillator and the enable input of the buffer amplifier for enabling said voltage controlled oscillator and said buffer amplifier only during a transmission from the transmitter thereby to reduce power drain and ensure adequate settling time.

41. The spread spectrum transmitter according to claims 34, 35 or 36, further comprising:

modulation index setting means for setting a frequency deviation of the voltage controlled oscillator in response to

modulating signals applied to the modulation input of the VCO to generate fast frequency shift keying (FFSK) in order to minimize transmitted bandwidth.

42. The spread spectrum transmitter according to claim 37, further comprising:

modulation index setting means for setting a frequency deviation of the voltage controlled oscillator in response to modulating signals applied to the modulation input of the VCO to generate fast frequency shift keying (FFSK) in order to minimize transmitted bandwidth.

43. A spread spectrum transmitter according to claims 34, 35 or 36, further comprising:

an address storage device for storing addresses;

error detection generation means for detecting error in data to be transmitted; and

means for applying addresses stored in the address storage device and error detection signals generated by the error detection generation means to the modulation input of the VCO at an amplitude less than the amplitude of the chip code applied to the modulation of the input by the chip code generator, thereby sequentially modulating the output frequency of the voltage controlled oscillator less broadly than when the chip code alone is applied to the modulation input of the voltage controlled oscillator.

44. A spread spectrum transmitter according to claim 37, further comprising:

an address storage device for storing addresses;

error detection generation means for detecting error in data to be transmitted; and

means for applying addresses stored in the address storage device and error detection signals generated by the error detection generation means to the modulation input of the VCO at an amplitude less than the amplitude of the chip code applied to the modulation of the input by the chip code generator, thereby sequentially modulating the output frequency of the voltage controlled oscillator less broadly than when the chip code alone is applied to the modulation input of the voltage controlled oscillator.

45. The spread spectrum transmitter according to claims 34, 35 or 36, further comprising:

multiplication means for multiplying the frequency output by the voltage controlled oscillator by a predetermined integer multiple of the frequency of the voltage controlled oscillator to produce a desired carrier frequency.

46. The spread spectrum transmitter according to claim 38, further comprising:

means for limiting a length of a data message transmitted so that once initial spread spectrum synchronization is achieved by a receiver, a receiver can run open loop without performing chip code synchronization.

47. The transmitter of Claims 34, 35 or 36, further comprising:

said chip code generator means generating a chip code sequence repetition at a chip rate of approximately 1.0-1.3 Mc/s

to produce a frequency shift keying (FSK) spread spectrum modulated signal.

48. A spread spectrum transmitter comprising:

carrier generation means for generating a modulated carrier signal, said carrier generation means including a modulation input for application thereto of a modulating signal;

a buffer amplifier, having an enable input, for amplifying the modulated carrier signal generated by said carrier generation means;

a filter connected to an output of the buffer amplifier for filtering the output of the buffer amplifier;

an antenna connected to an output of the filter;

processor means for controlling transmissions by said carrier generation mean, including,

processor oscillator means for producing a reference signal for stabilizing the carrier signal,

means for stabilizing the carrier signal by means of the reference signal produced by said processor oscillator means, and

chip code generator means clocked by the processor oscillator means for producing a chip code signal applied to the modulation input of said carrier generation means, thereby producing at the antenna a spread spectrum carrier frequency coherently locked to chip code generation means;

timer means for defining a low current inactive mode and an active operating mode in which the processor means, the carrier generation means and the amplifier are enabled;

wake-up means having an external input and a timer input from said timer means for enabling said processor means, carrier

generation means and amplifier means in accordance with the external input and the input from the timer means; and

said processor means further comprising means for generating plural active mode transmit messages thereby providing transmitted message redundancy.

49. The transmitter of Claim 48, wherein said processor means comprises:

means for applying a data message to the modulation input of said carrier generation means; and

means for limiting the length of the data message so that once initial spread spectrum synchronization is achieved by a receiver, the receiver can run open loop without performing continuous chip code synchronization.

50. The transmitter of Claims 48 or 49, wherein said carrier generation means comprises:

a voltage controlled oscillator having a modulation input modulated by said processor means to produce a FSK modulated signal.

51. The transmitter of Claim 48, wherein said carrier generation means comprises:

a tuned oscillator; and

a phase shift keyed modulator coupled to said tuned oscillator and having a modulation input modulated by said processor means to produce PSK modulated signal.

52. The transmitter of Claim 49, wherein said carrier generation means comprises:

a tuned oscillator; and

a phase shift keyed modulator coupled to said tuned oscillator and having a modulation input modulated by said processor means to produce PSK modulated signal.

53. The transmitter of Claims 48 or 49, further comprising:

said chip code generator means generating a chip code sequence at a chip rate of approximately 1.0-1.3 Mc/s to produce a frequency shift keying (FSK) spread spectrum modulated signal.

54. The transmitter of Claims 28, 51 or 52, further comprising:

said chip code generator means generating a chip code sequence at a chip rate of approximately 1.0-1.3 Mc/s to produce a phase shift keying (PSK) spread spectrum modulated signal.

55. A spread spectrum transmitter comprising:

oscillator means, including a voltage controlled oscillator having a modulation input, for generating a transmitter output at a carrier frequency;

processor means for controlling transmissions by the voltage controlled oscillator, said processor means including processor oscillator means for producing a frequency stabilizing reference clock signal;

means for stabilizing the frequency of the voltage controlled oscillator by locking the frequency of the voltage controlled oscillator to the frequency stabilizing reference clock signal produced by said processor oscillator means; and

said processor means further comprising chip code generator means clocked by the processor oscillator means for generating a chip code signal applied to the oscillator means, thereby locking the transmitter carrier frequency to the processor

reference clock signal with the processor reference clock in a fixed relationship with the carrier frequency.

56. The transmitter of Claim 55, further comprising:

said chip code generator means generating a chip code sequence repetition at a chip rate of approximately 1.0-1.3 Mc/s to produce a frequency shift keying (FSK) spread spectrum modulated signal.

57. The transmitter of Claim 55, wherein said carrier generation means comprises:

a tuned oscillator; and

a phase shift keyed modulator coupled to said tuned oscillator and having a modulation input modulated by said processor means to produce PSK modulated signal.

58. The transmitter of Claim 57, further comprising:

said chip code generator means generating a chip code sequence repetition at a chip rate of approximately 1.0-1.3 Mc/s to produce a phase shift keying (PSK) spread spectrum modulated signal.

59. The method of Claim 3, wherein the oscillator is modulated with fast frequency shift key (FFSK) modulation.

60. The method of Claim 1, wherein at least one of the data applied to the modulation input causes a priority transmission at an increased rate of message transmission.

61. The method of Claims 1 or 60, comprising:

transmitting repetitively a supervisory message.

62. The transmitter of Claims 12, 21, 29 or 32, wherein at least one of the data applied to the modulation input causes a priority transmission at an increased rate of transmission.

63. The transmitter of Claims 12, 21, 29 or 32, comprising:

means for initiating repetitive transmission of a supervisory message.

64. The transmitter of Claim 62, comprising:

means for initiating repetitive transmission of a supervisory message.

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